

REPORT DOCUMENTATION PAGE

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4. TITLE AND SUBTITLE Measurement of Lung Vibration from Low Frequency Underwater Sound in an Animal Model and Divers Using NIVAMS				5. FUNDING NUMBERS N000149710949	
6. AUTHOR(S) Peter H. Rogers					
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Georgia Institute of Technology Woodruff School of Mechanical Engineering Atlanta, GA. 30332-0405				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Office of Naval Research Biological and Biomedical Science and Technology Div. Code 335 Ballston Tower I 800 North Quincy St. Arlington VA, 22217-5660				10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES Attached report was submitted electronically.					
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13. ABSTRACT (Maximum 200 words) The attached report covers the activities performed in the past year. These include the design, fabrication, and testing of a travelling wave chamber for the controlled exposure of small mammals to underwater low frequency sound. They also include preparations for an experiment which is to be performed on divers in October 1998.					
14. SUBJECT TERMS Underwater Low Frequency Sound, Lung Vibration, Damage Thresholds				15. NUMBER OF PAGES 6	
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August 19, 1998

In reply refer to: **E-25-A54**

Mr. Robert Gisiner
Office of Naval Research
ONR 335, Ballston Centre Tower One
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Arlington, VA 22217-5660

Subject: **ANNUAL PERFORMANCE REPORT (W/ SF 298)**
Project Director: Peter Rogers
Telephone No.: (404)894-3235
Contract No.: **N00014-97-1-0949**
Prime No.:
**"MEASUREMENT OF LUNG VIBRATION FROM LOW FREQUENCY
UNDERWATER SOUND IN AN. . ."**
Period Covered: 97 0701 through 980630

The subject report is forwarded in conformance with the contract/grant specifications.

Should you have any questions or comments regarding this report(s), please contact the Project Director or the undersigned at 404-894-4764.

/TW

Sincerely,

Wanda W. Simon
Reports Coordinator

Distribution:
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800 N. Quincy St., Arlington, VA 22217-5468



Biomolecular and Biosystems Science & Technology Division (ONR Code 335) Fiscal Year 1998 Annual Report

1. Personal Information

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Contract/Grant Number: N000149710949

Contract/Grant Title: Measurement of Lung Vibration from Low Frequency Underwater Sound
in an Animal Model and Divers Using NIVAMS

AASERT

Contract/Grant Number: N000149

AASERT

Contract/Grant Title:

Program Officer: Gisiner

2. Objective

What is your scientific/technical objective? (<50 words)

We would like to estimate the damage threshold for human lungs exposed to underwater low frequency sound (ULFS) as a function of frequency and depth.

3. Approach

How do you plan to accomplish your scientific/technical objective? (<50 words)

We plan to determine the displacement frequency response of human and animal lungs when exposed to ULFS using an ultrasound system known as NIVAMS. We will compare these measurements to determine the relevant scaling factors and to extrapolate known lung damage thresholds for animals to those for humans.

4. Progress (for the 12 month period ending 1 July 1998)

What have you accomplished? (<400 words)

We have designed, modelled, fabricated, and tested a travelling wave tube which simulates an open water (free field) ULFS exposure for rodents on a laboratory scale. The tube is capable of producing travelling waves or pure pressure and pure velocity exposures. The tube produces exposure levels up to 210 dB in the frequency range up to 500 Hz. We have designed, prototyped, and tested a novel open loop control scheme to reduce the mass loading effects of the tube's drive piston on the subject rodent. This should extend the operating frequency range of the device to over 1 KHz. We have constructed two additional travelling wave tubes based on the same design. We have planned a diver study to determine the frequency response of human lungs. We have written and submitted the protocol for this study. In preparation, we have measured the acoustic field within the proposed test facility. We have, also, designed and fabricated numerous modifications to the existing NIVAMS system in so that it can be utilized in the study.

5. Significance

What is the impact of your accomplishments? (<50 words)

We have demonstrated analytically and experimentally the difficulty of producing a known ULFS exposure. We have proposed and designed a device with which this can be accomplished.

6. Work Plan (next 12 months)

What will you do next? (<100 words)

We plan to deliver two of the travelling wave tubes to the Naval Submarine Medical Research Laboratory (NSMRL) this fall. These will have functioning active control systems for the reduction of piston mass effects. We will conduct a diver study in October in order to determine the frequency response of human lungs. We will integrate the data from this study with data taken on animals using the tubes and other, preexisting animal data to estimate the

7. Technology Transfer

Technology transfer is an important measure of the relevance of scientific & technical endeavors. ONR Program Officers will use the information you provide here to highlight the technological payoffs that can emerge from investments in research.

Please describe any recent (last two years) direct or indirect interactions you may have had with Navy, other DOD, or industrial scientists and engineers. You should describe only those interactions that resulted in their use of methodology, data, software, or other developments produced or directly derived from your ONR support. If technology transfer occurred without such interactions, please describe that as well.

Finally, briefly describe what future plans you may have for technology transfer based on your ONR project.

The travelling wave tubes produced by this project will reside at NSMRL where they will be used for ongoing animal studies and provide a resource for other universities and research institutions wishing to study the effects of ULFS.

8. ONR Database Statistics for ONR supported research for the 12 month period ending 1 July 1998

The following information will assist with statistical reports:

0 Number of Papers Published in Refereed Journals Citing ONR Support

0 Number of Papers in Press Citing ONR Support in Refereed Journals

0 Number of Books or Chapters Published Citing ONR Support

0 Number of Books or Chapters in Press Citing ONR Support

3 Number of Technical Reports & Non-Refereed Papers

0 Number of Invention Disclosures Citing ONR Support

0 Number of Patents Granted Citing ONR Support

0 Number of Patents Pending Citing ONR Support

1 Number of Presentations

0 Number of Degrees Granted

2 Number of PI/co-PI (*Total*)

- **0** PI/co-PI Women
- **0** PI/co-PI Minority

0 Number of Grad Students (*Total*) ***

- **0** Grad Students Women
- **0** Grad Students Minority **

0 Post Doc (*Total*) ***

- **0** Post Doc Women
- **0** Post Doc Minority **

****** *Under-represented or minority groups include Blacks, Hispanics, and Native Americans. Asians are not considered an under-represented or minority group in science and engineering.*

******* *Supported at least 25% this year on contract/grant.*

9. List Refereed Journal Articles Citing ONR Support

10. List Books/Chapters Citing ONR Support

11. List Printed Technical Reports and Non-Refereed Papers Citing ONR Support

NSMRL Experimental protocol: "Measurement of Lung Vibration from Low Frequency Underwater Sound in Divers", Martin and Rogers, 7/98 (62 pgs) Technical Report: "Bubble Dynamics Near a Free Surface", Lewis and Rogers, 3/98 (3 pgs) Technical report : "Test Chambers for LFS Animal Exposures", Rogers and Lewis, 1/98 (21pgs)

12. List Presentations

"Test Chamber for Determining Damage Thresholds for High Amplitude Underwater Sound Exposure in Animal Models", Lewis T.N., et.al., J. Acoust. Soc. Am., Vol. 103, No. 5, Pt. 2, May 1998, pp 2756

13. List Patents Issued and Pending Citing ONR Support *(Provide Title, date, number)*

14. List Invention Disclosures Citing ONR Support *(Provide Title, date)*

15. Honors/Awards/Prizes

For each, please enter the name of the recipient, the recipient's institution, the name of the award, and the sponsor of the award.

16. Other Sponsored Work

Please enter your (PI) involvement with other sponsored research and development

For each project, please enter the Title, Sponsor (Agency), Funding (in \$K), Start Date and End Date.

"Underwater Acoustic Research", 10/97 - 12/99, \$4.9M, ONR "Confromal Aperture Velocity Sonar (CAVeS), 10/94 - 12/99, \$14.8M, ONR "Training for CAVeS Sonar Program", 5/96 - 4/99, \$147K, ONR "Prototype for State Switched Leave Behind Source", 3/97 - 12/98, \$257K, DARPA



Web site hosted by the Office of Naval Research

author: Eric Eisenstadt

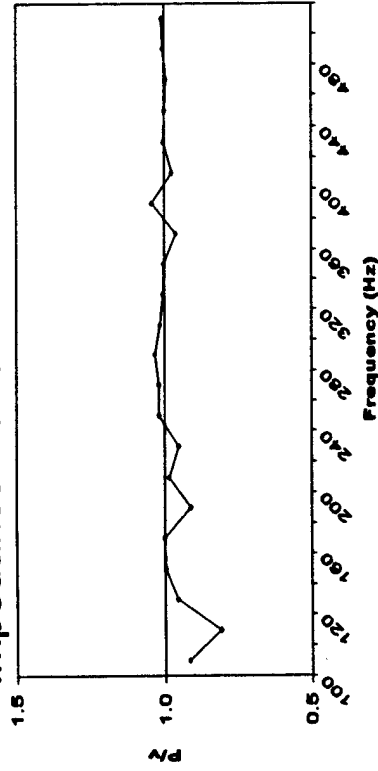
maintained by: WEBMASTER

last modified: 09 June 1998

Lung Vibrations Due to Underwater Low Frequency Sound (ULFS) Exposure

P. H. Rogers, Georgia Institute of Technology

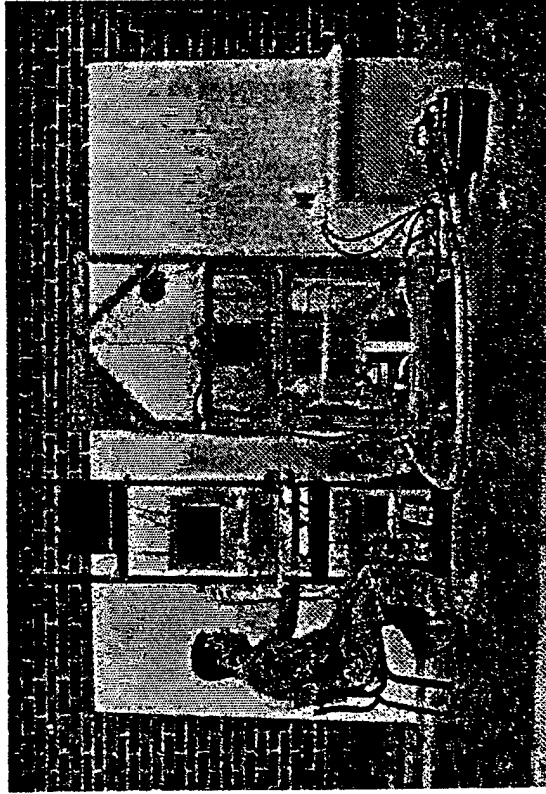
Impedance Relation Inside Chamber



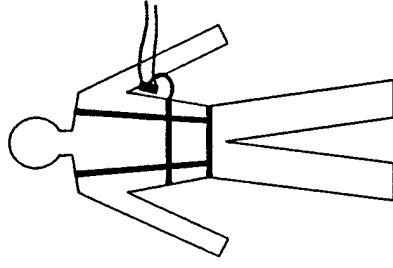
Objective: Estimate the damage threshold for human lungs exposed to ULFS as a function of frequency and depth.

Accomplishments:

- Travelling wave chamber for animal exposures designed, built, and tested ($\sim 206 \text{ dB re } 1 \mu\text{Pa}$).
- Human experiments planned.
- Human measurement system designed.



Animal Exposure Chamber



Significance: Developing safety criteria for divers who may be exposed to high intensity ULFS.

Diver Measurement System